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The Atlantic Coast of Maryland, Sediment Budget Update

by Joseph C. Reed

PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) describes a case study to update the sediment budget along the Atlantic Ocean within the US Army Corps of Engineers (USACE) Baltimore District's (NAB) area of responsibility. The area of interest includes the entire coastline along the open ocean between the Maryland/Delaware and Maryland/Virginia state lines. Active projects existing within the limits of this task include the Atlantic Coast of Maryland Shoreline Protection Project, the Assateague Island Environmental Restoration Project, Stinky Beach (Section 111–Rivers and Harbors Act), the navigational structures at the Ocean City Inlet, and a number of federally authorized channels. These projects consist of a variety of facets designed to control sediment either by mitigating erosion, navigational channel infilling, and/or sustaining natural environments. This effort was supported by the NAB and the USACE Engineer Research and Development Center (ERDC) through the Regional Sediment Management (RSM) Program and the Dredging Operations Technical Support (DOTS) Program.

INTRODUCTION: The approximately 31 miles of coastline fronting the Atlantic Ocean within the State of Maryland consists of barrier islands separated by the Ocean City Inlet. Since the Ocean City Inlet originally formed in 1933, anthropomorphic effects have been proliferated in the form of dredging, armoring, and placement of offshore borrow material. Over the past few years, several sediment budgets have been created to identify sources, sinks, and sediment pathways. The most recent of these budgets covered the 1995–2002 and 2004–2008 epochs (Offshore and Coastal Technologies, Inc. 2011), leaving the most recent 5 years (yr) (2008–2013) unaccounted for. Re-occurring engineering activities in the area include berm reconstruction (beach renourishment) at the Atlantic Coast of Maryland Shoreline Protection Project over approximately 4 yr intervals, biannual manual bypassing of material from the ebb/flood shoal to Assateague Island, and periodic maintenance of the federally authorized navigation channels.

The entire extent of the past sediment budgets is shown in Figures 1 and 2. The update of the sediment budget is tiered with the Atlantic Coast of Maryland Shoreline Protection Project sediment budget updated first and the remainder of the NAB's area of responsibility to follow.

METHOD: The goal of the RSM program is to use regional approaches and best management practices to improve the management of sediments and projects, increase economic savings and environmental benefits, and improve collaboration with stakeholders and sponsors (Rosati et al. 2001). In an area where so many anthropomorphic activities are being undertaken, it is the goal of the Project Development Team (PDT) to maximize the placement of material so that it is executed in the utmost efficient manner. It is also the intent of the PDT to determine how engineering activities are affecting the natural sediment movement in the area.

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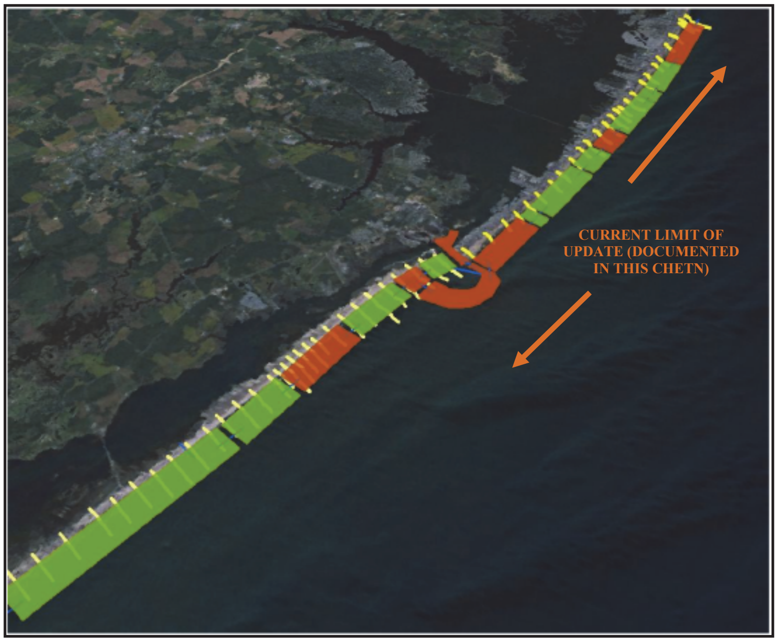

Figure 1. Extent of past sediment budgets (red = net loss; green = net gain).

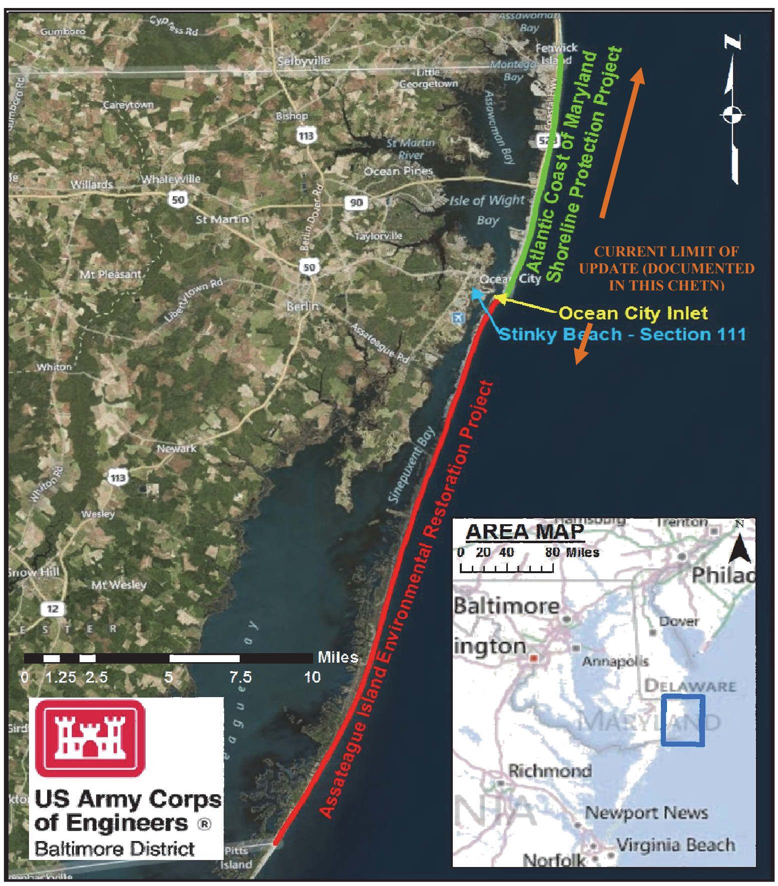

Figure 2. Active USACE Baltimore District projects within the area of interest.

For the Atlantic Coast of Maryland Shoreline Protection Project, volume change during the 2008–2013 epoch was obtained by analyzing each set of 28 profiles that were collected in May 2008 and May 2013. Each profile included data that extended from the landside of the dune out past the depth of closure. To compare the updated sediment budget with previous products, the limiting depth was taken as -30 feet (ft) North American Vertical Datum of 1988 (NAVD88). Previous analyses have indicated that the depth of closure (theoretical limit where there is no significant net cross-shore sediment transport) in this area is shallower than the limiting depth used for this analysis. The profiles were analyzed using the Beach Morphology Analysis Package (BMAP) (Sommerfeld et al. 1993; Sommerfeld et al. 1994; Wise 1995), and the Regional Morphology Analysis Package (RMAP) (Batten and Kraus 2004, 2005; Connell and Larson 2007; Morang and Kraus 2009), as contained in the USACE Coastal Engineering Design and Analysis System. Placement of material into each cell (a cell consists of a discrete compartment between each surveyed profile) was quantified by comparing the pre-placement survey to the post-placement survey that was taken as part of the 2010 berm reconstruction (beach renourishment). Altogether, 644 profiles were used from the 2010 construction contract to determine the amount of sand placed.

Results from the volumetric analyses were imported into the stand-alone version of the USACE Sediment Budget Analysis System (SBAS) (Rosati and Kraus 1999, 2001; Dopsovic et al. 2002; Podoski 2013). Two different alternatives were calculated. Alternative 1 consisted of applying the assumption that the volume change in the northernmost cell moved to the north. Alternative 2 assumed that no sand was transported to the north and that all sand is transported to the south.

RESULTS: In total, 931,780 cubic yards (cu yd) of material were placed during the 2010 berm reconstruction (beach renourishment) contract. This material, combined with the volumetric losses derived from the 2008 and 2013 datasets, was used to generate the two alternatives for the solution of the sediment budget at the Atlantic Coast of Maryland Shoreline Protection Project. As seen in Figures 3 and 4, while both alternatives produced overall net fluxes to the south, only Alternative 1 assumed any loss to the north. Of note is that the volumes shown in the two figures reflect the net loss of the entire epoch (2008–2013) and are in units of cubic yards.

The volume change for each cell, as derived using datasets collected at the beginning and end of the epoch as well as the volume of material placed during the 2010 berm reconstruction (beach renourishment) which were used to compile the sediment budgets, is included in Figure 5. As seen in Figure 5, areas of overall volume loss include cells 4–6 (138th Street–120th Street), 10–14 (92nd Street–69th Street), and 25–27 (10th Street–2nd Street). The extent and nature of these losses are discussed further in the following section.

While Figure 5 shows the *end-point* volume change over the 2008–2013 epoch as derived using a dataset at the start and end of the epoch, it does not provide the rate of volume change because it excludes the loss/gain of the placement material. By including the erosion or accretion of the material placed during the 2010 berm reconstruction (beach renourishment) contract with the end-point volume change and converting the resulting volumes to an annual change per linear foot of beach, erosional hotspots can be identified. For the purposes of this CHETN, an erosional hotspot is defined as a section of the beach which erodes at a higher rate than the remainder of the shoreline (Kraus and Galgano 2001).

Figure 3. Atlantic Coast of Maryland sediment budget, Alternative 1, developed for the sediment budget update. May 2008–May 2013 epoch. North littoral transport.

Figure 4. Atlantic Coast of Maryland sediment budget, Alternative 2, developed for the sediment budget update. May 2008–May 2013 epoch. All south littoral transport.

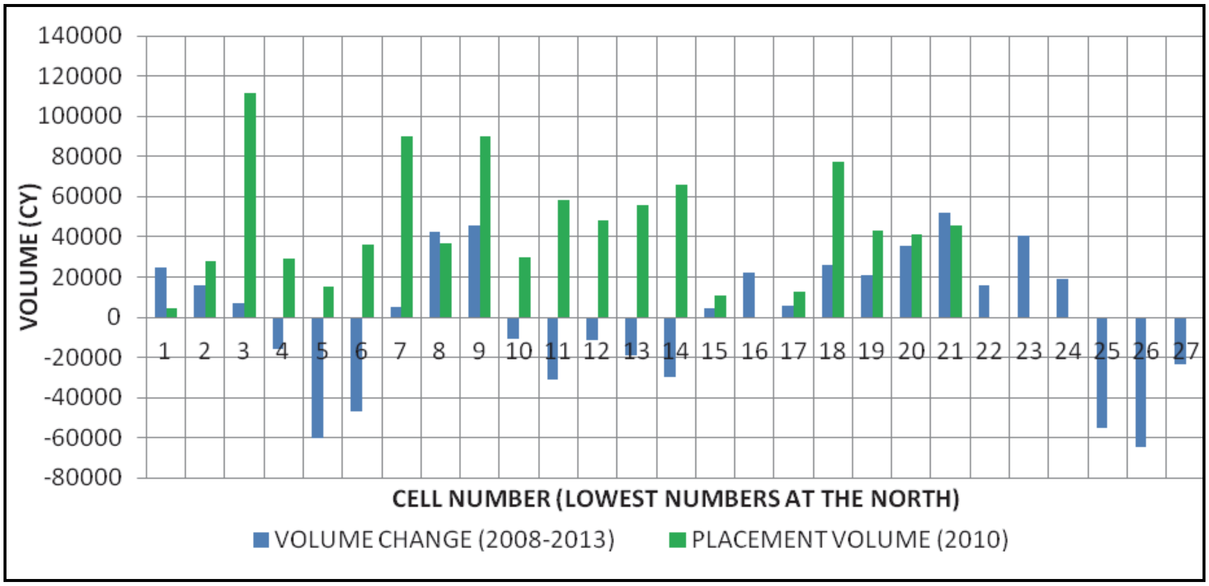

Figure 5. Volume change and placement dispersion during the 2008–2013 epoch.

The annualized volume change per linear foot of beach shown in Figure 6 includes the loss of the material that was placed in 2010 and the end-point volume change that was calculated over the entire epoch (2008–2013). As seen in Figure 6, erosional and depositional trends over the 2008–2013 epoch are evident, with the largest erosion rates present in cells 10–14 (92nd Street–69th Street) and 6–7 (124th Street–112th Street). Also noticeable is that there has been erosion along the southern limits of the project, which could indicate that material is being taken offshore into the inlet system. Recent observations related to the system's performance during and post Superstorm Sandy support these findings by the presence of a large sand shoal within the mouth of the inlet and by eyewitness accounts of large amounts of sand overwashing the jetty into the inlet during the storm.

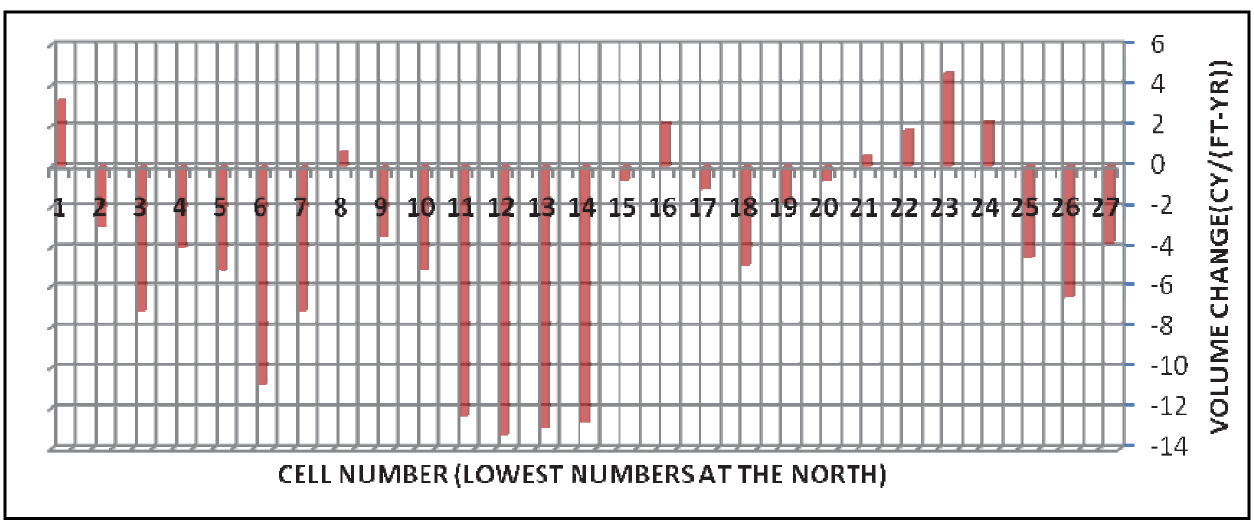

Figure 6. Rate of volume change per year during the 2008–2013 epoch.

DISCUSSION: Previous sediment budgets provided solutions to the Alternative 2 arrangement where the assumption was made that all sediment transport is to the south. As seen in Figure 7, the annual rate of sand flux into the ebb/flood tidal inlet system derived during this study for the 2008–2013 epoch correlates well with the results found by others for the 2004–2008 epoch (Offshore and Coastal Technologies, Inc. 2011). The slight increase in annual flux of sediment into the inlet system could be attributable to the recent storm activity due to Superstorm Sandy. Post Sandy, it was observed that a large mass of material had moved over the top of the north jetty and was present inside the mouth of the inlet. Based on qualitative indicators, end losses at the northern boundary of the project appeared to decrease during this epoch. This is most likely due to the decrease in diffusivity from the placement of material by the USACE Philadelphia District, as part of the Fenwick Island beach renourishment project.

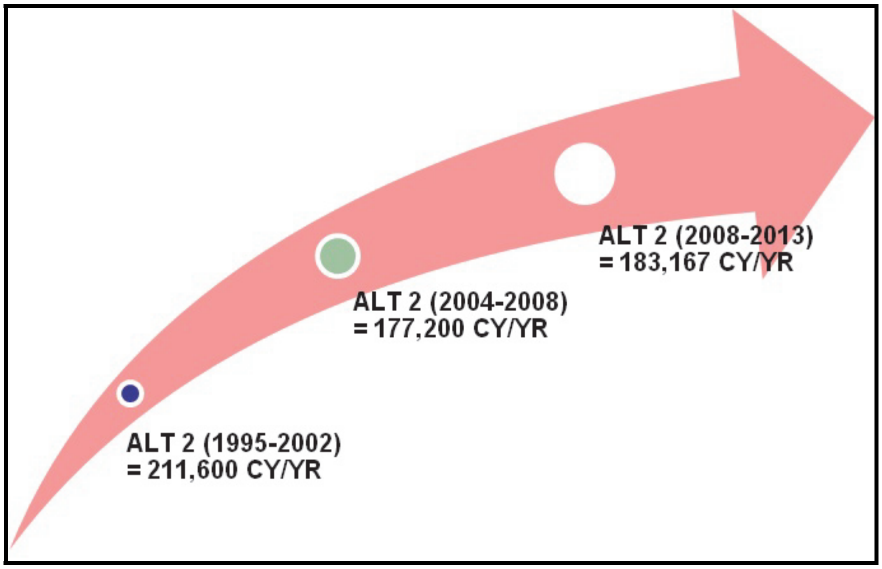

Figure 7. Historic annual sediment flux rates into the inlet system.

Locations on the shoreline where the direction of the littoral transport diverge are commonly referred to as *nodal points*. Historically, the presence and migration of a nodal point along Fenwick Island has been documented. In reviewing the sediment budget developed for the 2008–2013 epoch, it appears that the location of the nodal point has remained consistent, with the current location being in cell number 3 (between 146th Street and 138th Street).

Areas where overall loss of material was observed during the epoch include cells 4–6 (138th Street–120th Street), cells 10–14 (92nd Street–69th Street), and cells 25–27 (10th Street–2nd Street). Cells in which erosion persisted at levels greater than adjacent shoreline are evident within cells 10–14 (92nd Street–69th Street) and cells 6–7 (124th Street–112th Street). Not surprisingly, the areas with the largest erosion rates correspond well with known hotspots.

CONCLUSIONS: This CHETN documents the purpose, development, and outcomes of the first tier in the Atlantic Coast of Maryland Sediment Budget Update, as part of a greater plan to develop a regional sediment budget for the mid-Atlantic coastal zone. Areas of future study could pertain to pursuing the cause of the erosional trend evident at the southern end of the project boundaries. In particular, the possibility of wave interaction with the ebb shoal could be

explored to determine if it is having a detrimental effect on the adjacent beach. Additionally, as noted previously, the reduction of overwash during storm events could also be explored to reduce the maintenance dredging in the federally authorized navigation channels.

ADDITIONAL INFORMATION: This Coastal and Hydraulics Engineering Technical Note (CHETN) was prepared by Joseph Reed with technical review by Thomas Laczo, Robin Armetta, and Robert Blama, all with the US Army Corps of Engineers, Baltimore District (NAB), Baltimore, Maryland. Funding for this study was provided by the USACE Regional Sediment Management (RSM) Program. Additional information pertaining to the RSM Program can be found at *http://rsm.usace.army.mil*.

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ACRONYMS AND ABBREVIATIONS

Term	Definition
BMAP	Beach Morphology Analysis Package
CHETN	Coastal and Hydraulics Engineering Technical Note
CHL	Coastal and Hydraulics Laboratory
CY	Cubic Yard
DOTS	Dredging Operations Technical Support
ERDC	Engineer Research and Development Center
GIS	Geographic Information System
NAB	United States Army Corps of Engineers Baltimore District
OCTI	Offshore & Coastal Technologies, Inc.
PDT	Product Development Team
RSM	Regional Sediment Management
SBAS	Sediment Budget Analysis System
USACE	United States Army Corps of Engineers